

Coherent Inverse Primakoff-Bragg Conversion of Solar Axions in Single- Crystal Bolometers

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The CP Problem

“Generic” QCD *should* violate CP symmetry

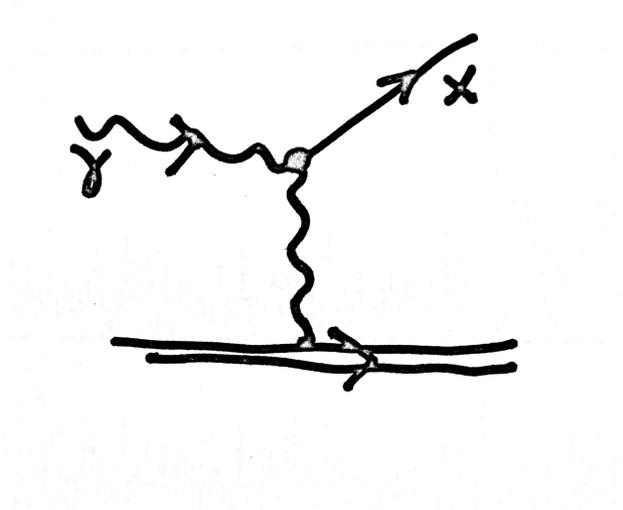
$$\Theta \sim 1$$

This would lead to d_N , but $d_N < 2.9 \times 10^{-26}$ e-cm

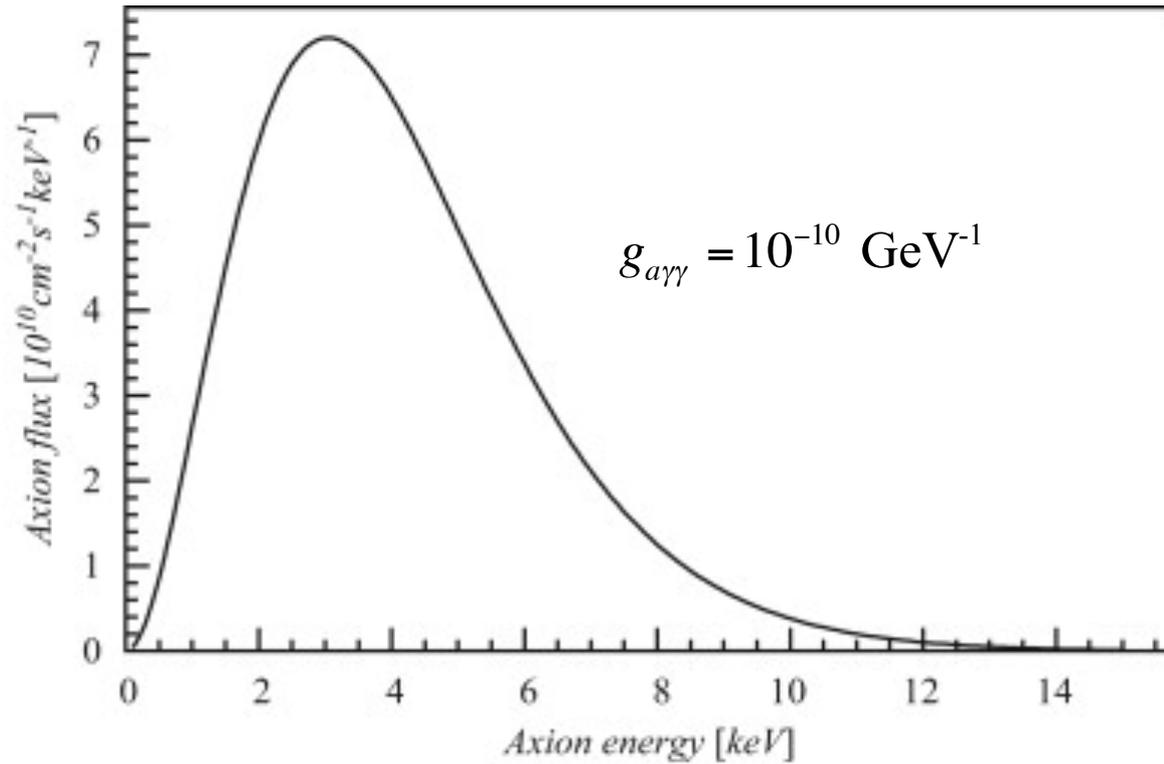
$$\Theta < 10^{-10}$$

Primakoff Effect

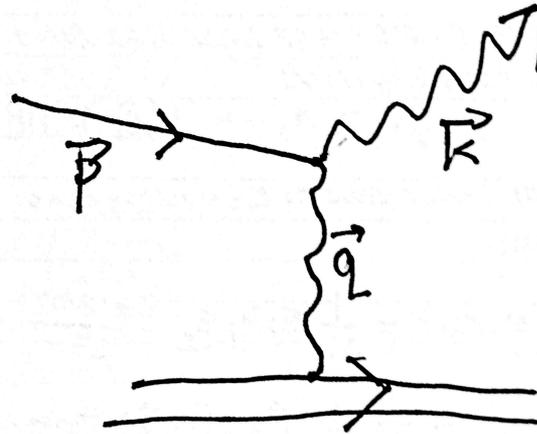
$$\mathcal{L} = g_{a\gamma\gamma} \vec{E} \cdot \vec{B} a$$

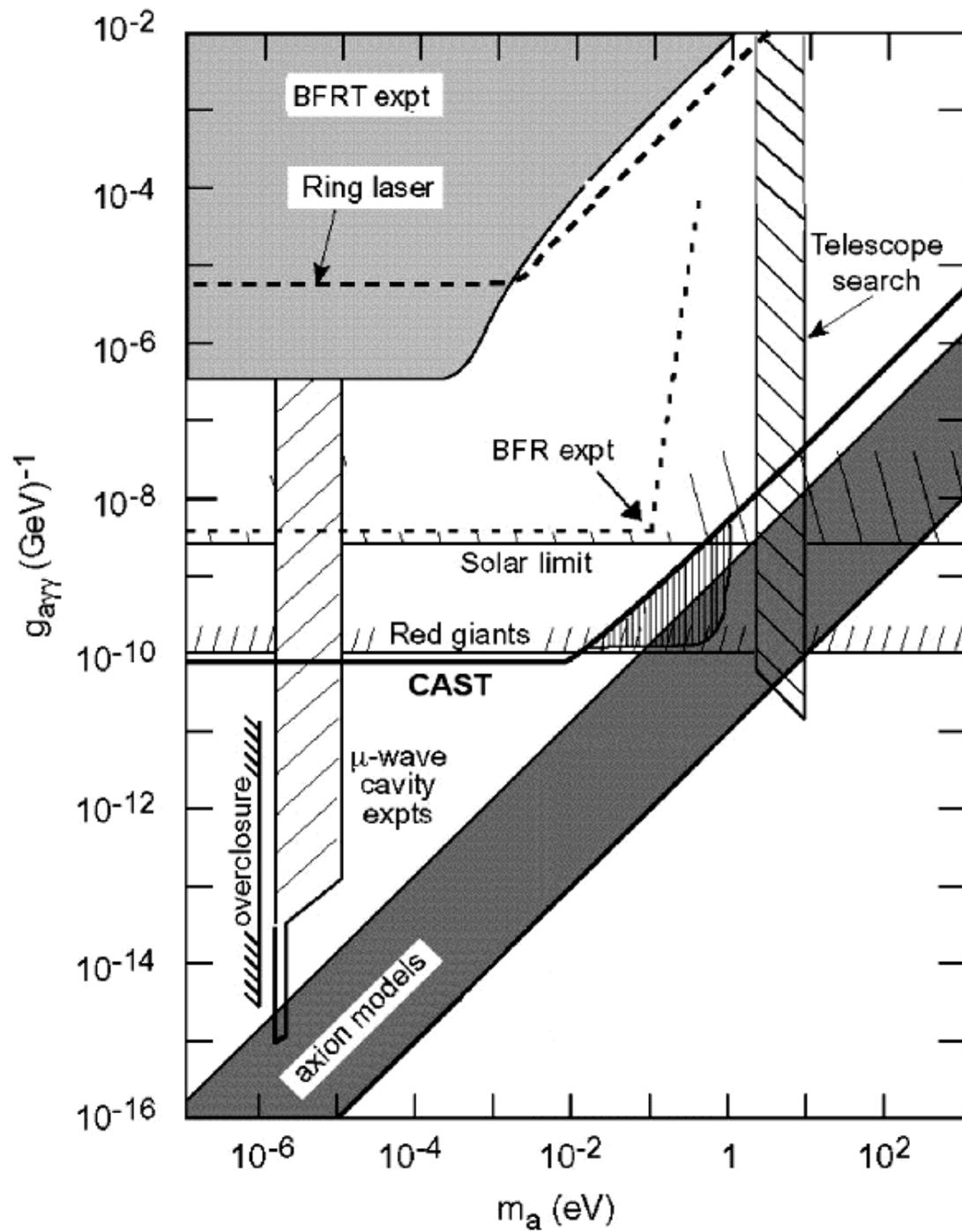


Solar Axion Flux (Primakoff Effect)



Inverse Primakoff Effect





Coherent Bragg Conversion

$$\rho(\mathbf{r}) = \sum_{\mathbf{R}} \rho_c(\mathbf{r} - \mathbf{R})$$

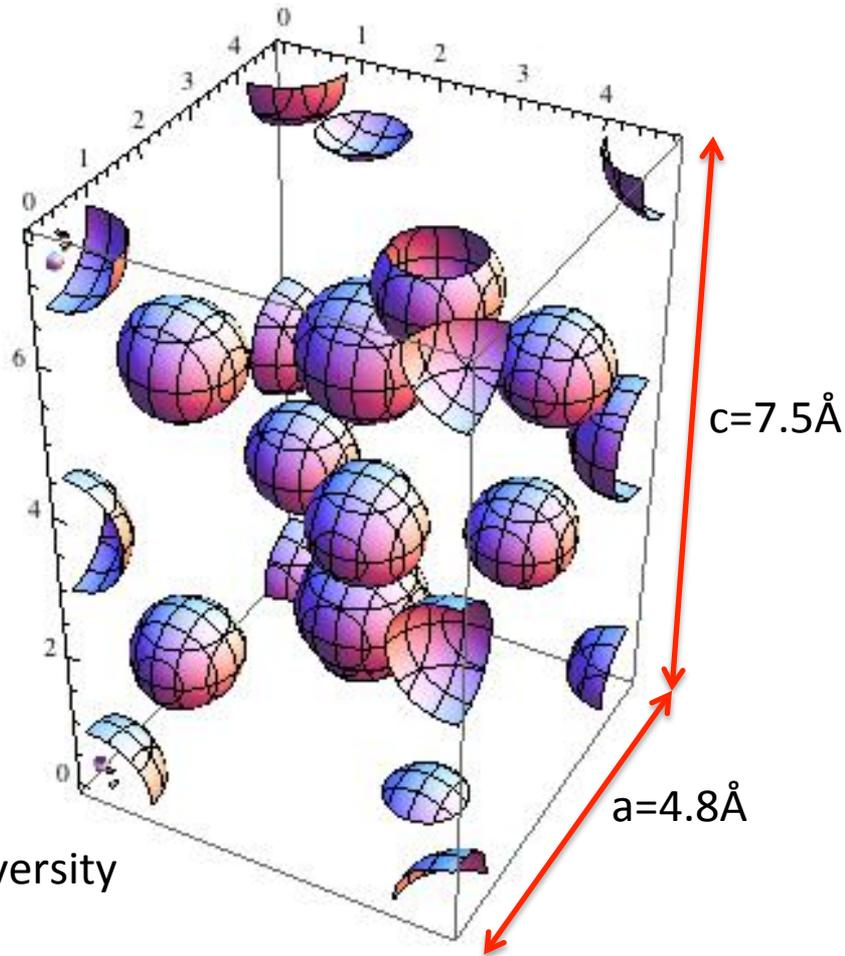
Lattice vector

Charge density in
a single unit cell

Charge Density of TeO₂

$$n_e = 272 e$$

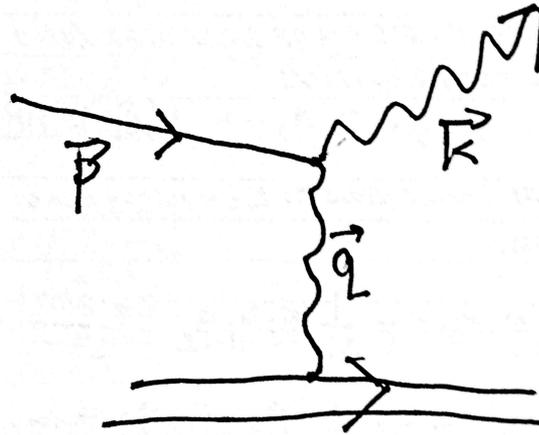
$$\rho = 0.2 e/a_B^3$$



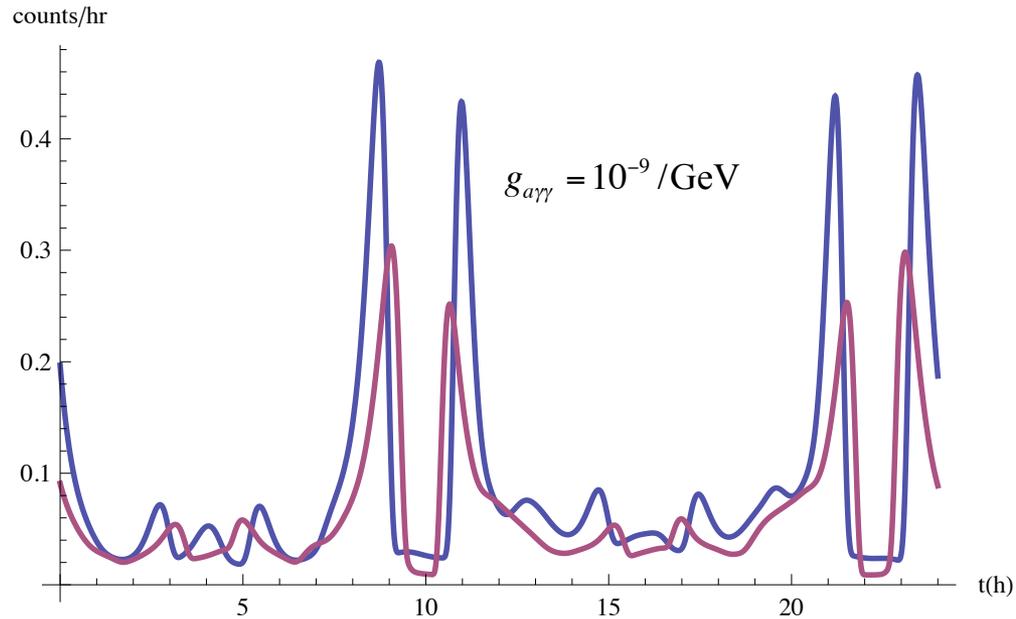
*Yuanxu Wang, Henan University
Wein 2k

Bragg Conditions

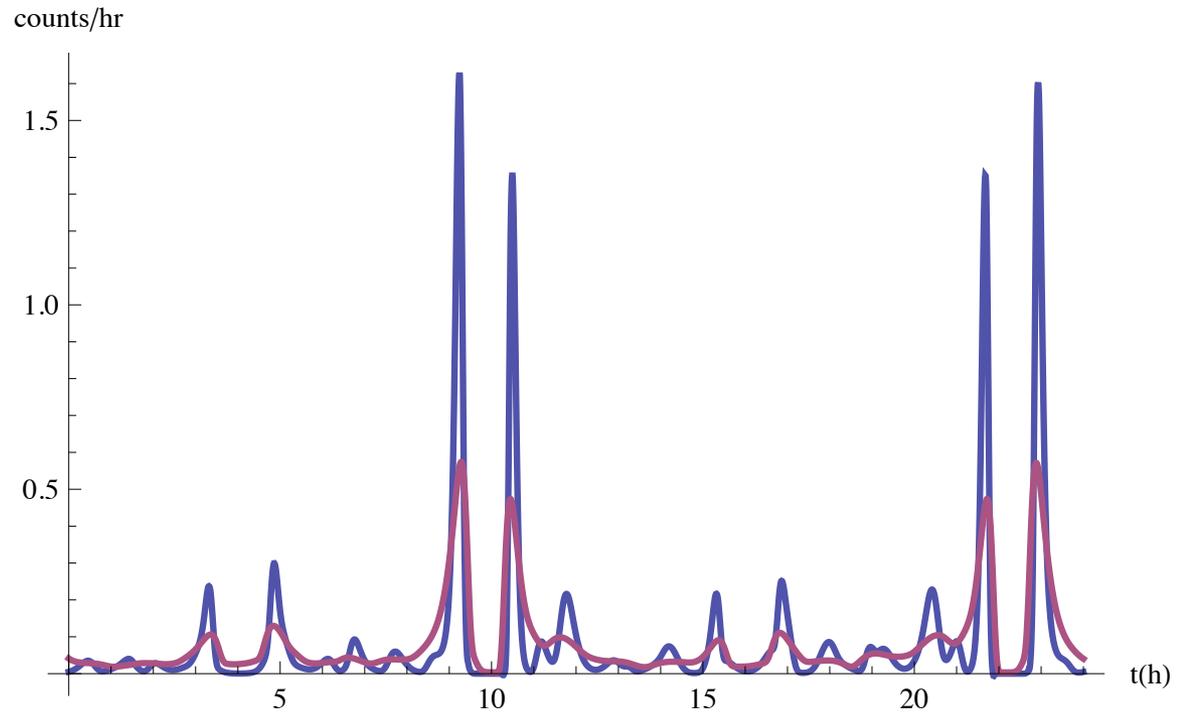
$$E_a = \hbar\omega \quad \mathbf{q} = \mathbf{G} \text{ (a reciprocal vector)}$$



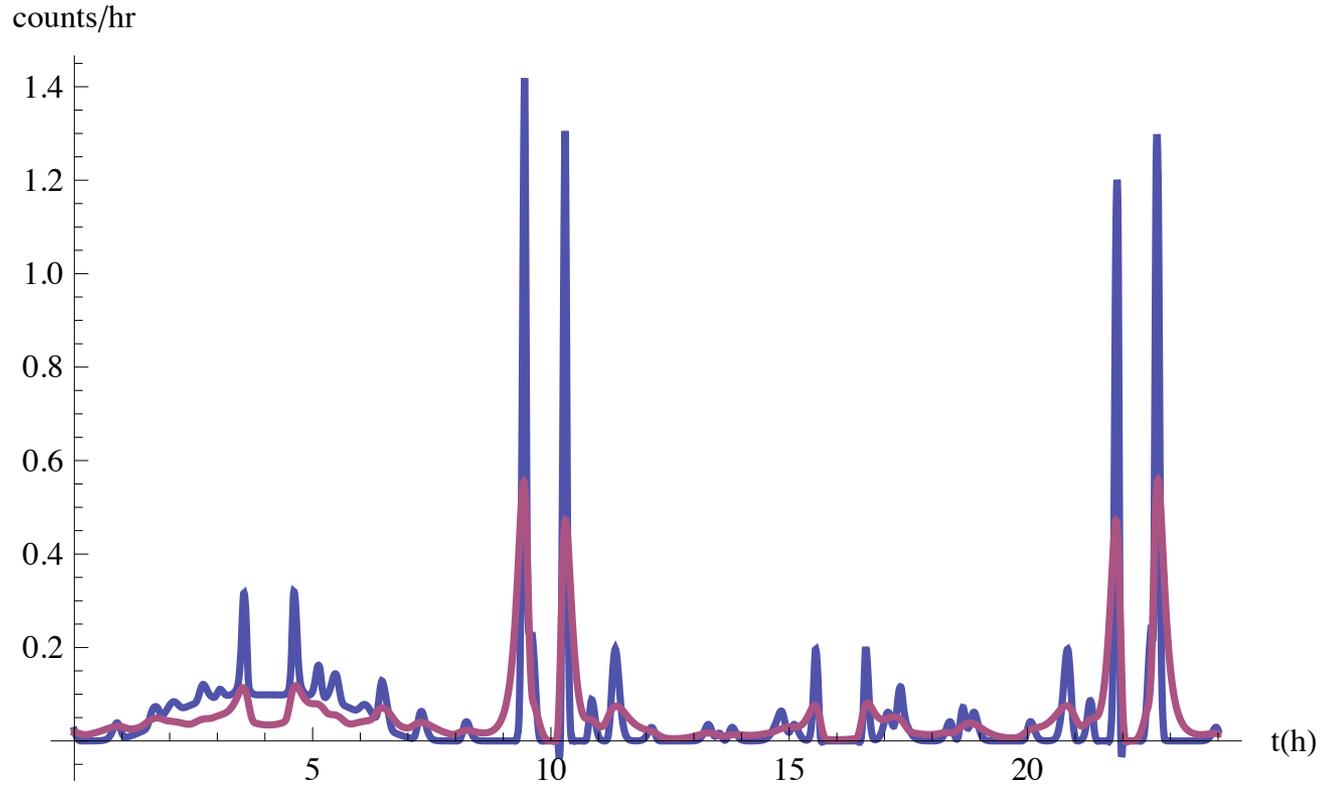
Coherent Bragg/Primakoff Conversion



$E_x = 2.0 \text{ keV}$ $w = 0.5 \text{ keV}$ (blue) $w = 1.5 \text{ keV}$ (red)

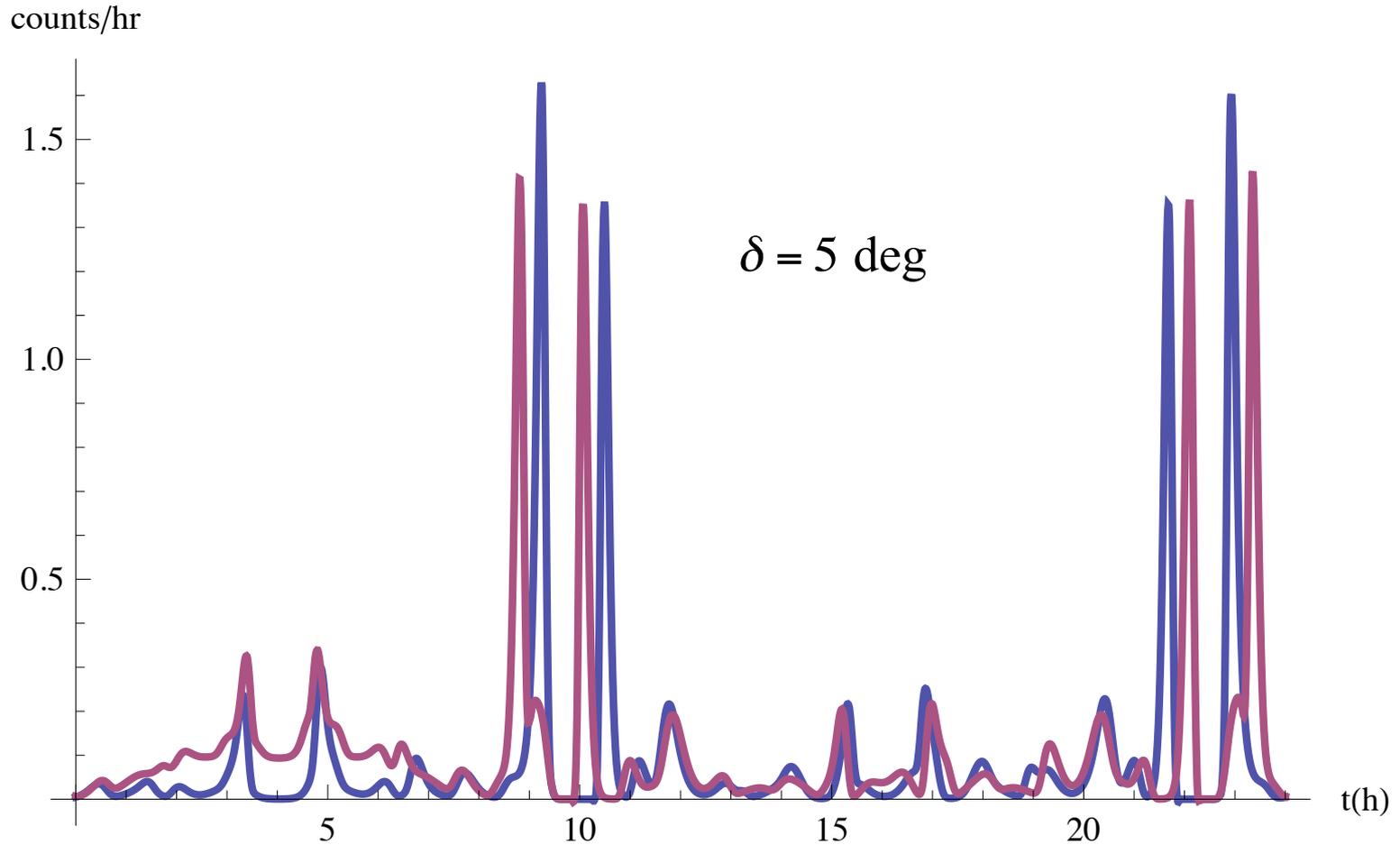


$E_x = 4.0 \text{ keV}$ $w = 0.5 \text{ keV}$ (blue) $w = 1.5 \text{ keV}$ (red)



$E_x = 6.0\text{keV}$ $w=0.5\text{ keV}$ (blue) $w=1.5\text{ keV}$ (red)

Sensitivity to Crystal Alignment



Statistical Analysis of Sparse Events

$$\chi = \sum_{i=1}^N w(t_i) n_i$$

Random variable

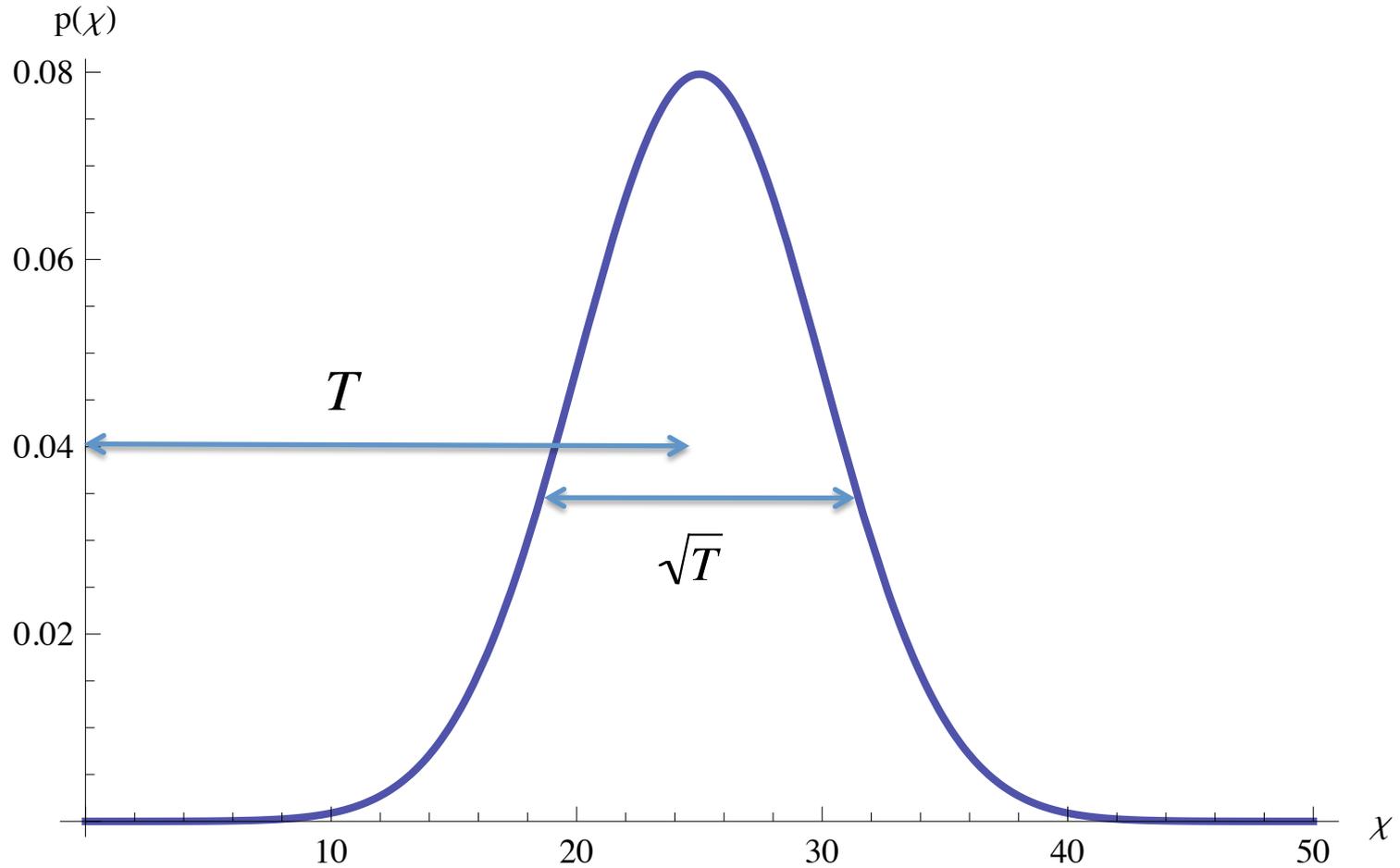
$$\langle n_i \rangle = R(t_i) \Delta t \ll 1$$

Weighting
function

$$\langle \chi \rangle = \int_0^T w(t) R(t) dt \quad \Delta \chi^2 = \int_0^T w^2(t) R(t) dt$$

$$p(\chi) = \frac{1}{\sqrt{2\pi\Delta\chi^2}} \exp\left[-\frac{(\chi - \langle\chi\rangle)^2}{2\pi\Delta\chi^2}\right]$$

Likelihood Function



Conclusions

- Bragg/Primakoff Conversion can search part of the interesting (dark matter) axion phase space.
- It is “free” ! All you have to do is orient the crystal bolometers.
- Sensitive to other types of ALPs and couplings.